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WARRIOR HOME

Resilience Narrative

U.S. Department of Energy
Solar Decathlon 2020
Build Competition

Kaikaiknong Crescent Development
Resilience Narrative
BC_WH_JURYRESIL
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> ***We intend to raise the bar for energy efficient, affordable, safe and healthy homes for our membership by continuously focusing on a holistic approach to our builds with improved standards, innovative partnerships and utilizing the latest building technology available.***

Greg Nadjiwon
Chief, Chippewas of Nawash

Introduction

The Chippewas of Nawash Unceded First Nations community located on the Neyaashiinigmiing Reserve in Southwestern Ontario forms an integral part of the rich tapestry that is Canada's indigenous heritage. Like many Indigenous communities, however, access to adequate housing for all of its members is often a large challenge and one that is not sufficiently addressed by provincial and federal governments. With growing families and the return of community members wishing to live on their lands, the demand for good-quality, affordable housing that meets the needs of each Chippewas of Nawash community member kept rising. As a result, Warrior Home's entry for the Solar Decathlon Build Challenge aimed to address the housing crisis present in Canada's Indigenous communities through the design and construction of a sustainable home that also addresses the cultural and societal needs of the homeowner and community.

From 2018 to 2020, Warrior Home has worked closely with the Chippewas of Nawash to design and build a net-zero energy home that was made to accommodate the specific needs of the residents of the Neyaashiinigmiing Reserve. The team was able to partner with the Habitat for Humanity Grey Bruce to build a net-zero energy home in the Kaikaiknong Crescent development. After extensive consultation with community leaders, community members and the family that was set to receive the home, Warrior Home was able to develop an innovative and affordable design that integrates energy efficient technology, high-performance engineering systems as well as aesthetics, ergonomics, and Indigenous cultural integration. By December 2019, students and local volunteers were able to complete the construction of the Warrior Home design and a family of 5 was able to move in.

Resilience was a core tenet of Warrior Home's Design philosophy and the Warrior Home team incorporated a variety of strategies to ensure a resilient design. For instance, the building envelope control layers were optimized to mitigate moisture penetration and build-up, and the structural components were designed with a high degree of redundancy to be able to endure disaster events. Enhanced insulation provides protection against the location's wide fluctuations in temperature, and heat recovery units controls the home's humidity. In this way, the long-term durability of the home is ensured.

What fueled the team to complete the design and help build the net-zero energy home were ultimately the wonderful people in the community, which include the housing authority, Chief and Band Council, the homeowners, a mother named Melissa and her four kids, and many others met throughout the process. Their unique stories and needs propelled the design for the home, which itself contributed towards the promotion of sustainable development within First Nations communities.

Durability

The design of the building enclosure optimizes the thermal performance of the building through the use of XPS insulation on the exterior and fiberglass batt insulation within the interior cavities. The choice to delegate some of the insulating controls to the exterior XPS was done to minimize thermal bridging through the wood studs. It also allowed a higher R-value to be achieved and negated the need to increase the width of the stud to accommodate for the same level of insulation. The material used is relatively standard; however, the positioning of each control layer incorporates recent research findings and techniques to prevent common problems that usually occur within building enclosures. The ideology of one-half of the insulation on the exterior, and one-half of the insulation on the interior is a design choice that resulted from a prior research conducted by the Cold Climate Housing Research Center (CCHRC). A variation of the R.E.M.O.T.E ideology was adapted for Warrior Home's circumstances, to best fit the client's needs while maintaining optimal energy efficiency. Furthermore, the home was designed to ensure comfort year round. Moisture build-up is prevented in the design, as significant build-up will lead to structural deterioration, mold and pest problems. All of these design decisions work together to ensure the completed build is durable and long-lasting.

Through both design and material choices the home was constructed to be durable and capable of resisting the extreme environmental conditions it is likely to experience throughout its life. The photovoltaic panels chosen were the Trina Solar DUOMAX M PLUS - DEG5 (Figure 1). These panels are not only lightweight and operate at 20% efficiency, but are resilient to real-world climate conditions like snowfall and fluctuations in temperature. With an expected service life of 25-30 years, the panels would provide green energy to the home for many years to come. The Solaredge SE10000A-US inverter was chosen for the inverter due to its high performance design at an economical price. This system's power conversion architecture performs at 98% efficiency and is designed with sophisticated digital control technology. The fixed-voltage technology ensures that the inverter is always working at optimal voltage regardless of the varying energy input from the solar panels.

Figure 1
Trina Solar DUOMAX M PLUS - DEG5
Image Source: Trina Solar

Materials selected for construction were chosen based on the desired performance of the home, combined with an understanding of the highly variable conditions the home would experience throughout the year. The most extreme environmental conditions being large fluctuations in environmental temperature and potential for heavy snowfall were considered in all aspects of design. Solar panels are angled such that snowfall will not accumulate, and the structural design of the home accounts for the increased weight of solar panels and expected snow loads.

Warrior Home's design also works to optimize the longevity of design including maintenance, material performance, and owner operation. A heat recovery ventilator unit was chosen to avoid bringing humidity back into the home and minimize the condensation gathering on the windows. This is a good building practice and promotes the longevity of the home. It exhausts from the stale, humid air and recycles the warmth to heat – or cool - incoming, fresh air. This reduces the risk of moisture damage and increases the lifespan of the windows. The recovered heat saves energy that would otherwise be consumed to heat the new air.

The selected heat pump is two-stage and can operate at partial output to reduce the electrical demand. It increases the longevity of the unit and is a more efficient system compared to running the pump at full capacity 24/7. It can also switch between operating in heating mode and cooling mode, essentially providing two units in one package.

Advanced framing used in the Warrior Home design increases the longevity of the house by minimizing P-delta effects that studs commonly experience due to eccentric loading. This means that there will be less stress in the members, which will result in an increase of the lifespan of the members and decrease in maintenance costs.

The studs in the home were spaced at 24" on centre, which is further apart than what is normally acceptable. Additionally, only one top plate is needed for advanced framing. This lowers material cost and increases the durability to cost ratio of the structure of the home. A 2x6 stud size was selected over 2x4 to increase the durability and stability of the home because larger cross sectional areas require more force for the same amount of internal stress. If Warrior Home had not chosen to implement

advanced framing and larger studs, the life cycle cost of the house would have been larger. This is because more members are required due to the closer spacing and the requirement of two top plates. This variance creates decreased maintenance costs, longer lifespan of materials, and cheaper up front material costs.

To further address and promote the longevity of the design, the homeowners were instructed on the proper use of all the technologies in their home (Figure 2), as well as habitual tasks they could do to extend the service life and reduce required maintenance.

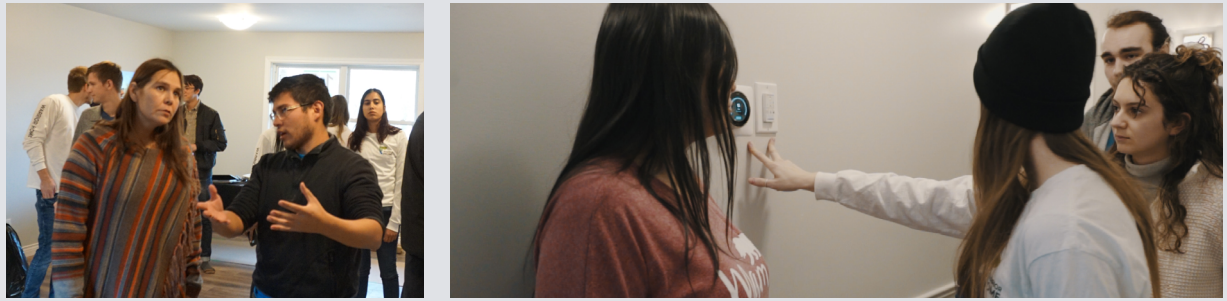

Figure 2
Warrior Home Team Members Explain Technologies in the Home to the Homeowner
Image Source: Warrior Home

Performance

The home is designed with great redundancy between the studs, joists, and trusses. Consequently, the structure is much better equipped to endure disaster events because a single member failure will not cause the whole structure to fail as the surrounding members may pick up the load. The structure was also designed to hold an increased load created by solar panels on the roof. This means that if a disaster caused a power outage for the community, the home's performance would be unaffected.

As the home is constructed from lightwood framing, it is the beneficiary of timber's attributes. Lightwood framed houses are very efficient at resisting loading created by disasters, such as seismic loads. The first reason for this is that timber is very light. Since seismic loads are proportional to the self weight of the structure, the forces taken by the structure would be lighter than those taken by a steel structure of similar size. Additionally, timber framed homes are very ductile systems. This is not because wood itself is particularly ductile, but the connections with nails are. Since thousands of nails are used in a home, there are thousands of opportunities for small plastic hinges to be formed to absorb energy through the ductility of the steel nail.

As mentioned, the advanced framing allows for greater spacing between studs. Greater spacing creates a higher insulation-to-stud ratio which helps the building maintain energy. This feature is most important during long cold spells which the region is frequently subjected to, as there are fewer opportunities for thermal bridging through the studs to occur. The structure's thermal performance is also aided by the raised heel trusses shown in Figure 3.

The raised heel truss created the space for 20" of R70 blown-in cellulose to be used. The added insulation is critical in preventing the roof from being a weak point for energy loss. Furthermore,

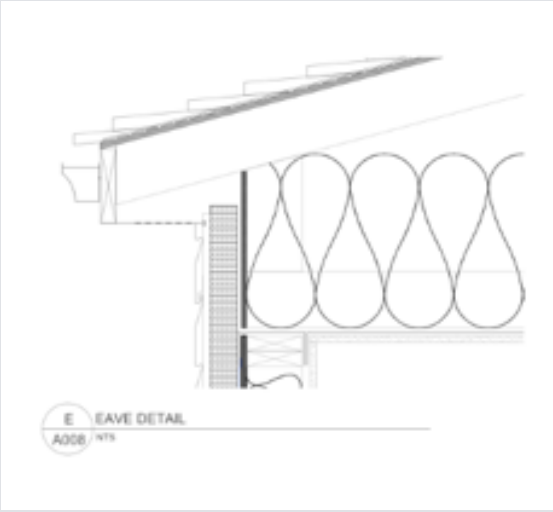

Figure 3
Raised Heel Truss Elevation View
Image Source: Warrior Home

advanced framing improved the building's resilience to extreme events. This is because the structure had more efficient load paths by having fewer members strategically placed. More direct paths from the roof to the foundation improve structural performance under increased loads because it avoids creating unnecessary stresses in members by transferring loads.

The building does not provide the ability to operate using on-site solar generation during a power outage. The building uses a grid tied inverter and net metering to achieve net-zero energy usage and does not incorporate battery storage, though it could be extended in the future. Adding battery storage to cope with infrequent outages would be prohibitively expensive.

Resource Management

Warrior Home placed an acute focus on holistically integrating passive strategies, material selection, life cycle and local strategies to maximize the resilience of the design. Resilience and durability relates closely with occupant comfort in the moisture control sector. With a poor building enclosure design, there is high potential for moisture build-up in the building assembly. Moisture build-up for extended periods without a method of drying could lead to structural deterioration, as well as mold and pest problems which pose a risk to poor occupant health and comfort. Furthermore, there are health risks associated with select thermal insulation materials. Some of the materials settle, or breakdown, as its lifespan wears out, which is related to both the resilience of the structure, as well as the occupant comfort and safety. Warrior Home's design ensures that these negative scenarios are mitigated or avoided entirely. The HVAC system consists of a central heat pump connected to an air handling unit (AHU) coupled with a heat recovery ventilator (HRV) unit - a system optimal for maintaining occupant comfort year-round.

The competition prototype is also resourceful in that it enables the reclamation and reuse of water. A rainwater collection system with a rainwater barrel is provided for the family. This encourages the reclamation and reuse of water, particularly in an outdoor setting. The homeowners can then re-use the collected water for outdoor activities.

$404
Annual Electrical Bill Savings

50%
Annual Water Bill Savings

NET ZERO

11,135 kWh
Less Energy Used per Year Compared to Baseline Average

Since the home is designed to be net zero, and the average home in Canada uses approximately 11,135 kWh of energy annually, the home can be said to require 11,135 kWh less energy than the baseline. Without consideration of net-metering, the home was designed to use 55% less energy than traditional homes of the same size. The heat pump uses a compressor and refrigerant to heat the water with ambient heat from the surrounding air instead of producing heat. In total, the heat pump is estimated to save up to $404 annually on the electricity bill.

> ***"We are going above and beyond to make our units more energy efficient so it translates into savings in operation and maintenance costs for our tenants."***

Shane Chegahno
Housing Manager, Chippewas of Nawash

Resilience Innovation

The Warrior Home design team made the innovative choice to implement advanced framing instead of standard framing for this build. Advanced framing places studs directly below joists or rafters in order for load to be transferred straight through the studs, greatly improving resilience at a low cost. Another innovative approach that the team made with regards to building resilience and occupant safety was the degree to ensure that there were strong lines of communication between the design team and the home owners. By ensuring that the homeowner had a thorough understanding of how best to use the technologies installed in their home and practices for ensuring the home remained as energy efficient as possible the continued resilience of the home could be ensured. This is an innovative step because it's something too scarcely considered during the design and construction process, with the designers usually only being concerned with how the building will perform on paper, as opposed to how it will perform while occupied by real individuals.

The team also used resilient design strategies to improve the house performance and occupant health in various regards. The design paid careful consideration towards the building envelope, and its interaction with the mechanical and structural systems. The goal was design and built to ensure that a simple, but high performing home was constructed that would not result in issues such as mold, rot, or pest infestation. Our partners at the Chippewas of Nawash highlighted that issues regarding mold, and generally poor living conditions were seen far too frequently on reserves. Breaking out of that was something the team strove for, not just in this design, but for the future as well. In designing our home with simplicity, efficiency and effectiveness, it was our hope that the Warrior Home could be used as a template for further development. Or hope became a reality as many homes have now been built on the same street as our design following the same architectural design and building envelope principle as our original home. In positively impacting both the house performance and occupant health of the house Warrior Home designed and built as part of this build challenge through simplicity and effectiveness, the innovative and compounding impact of our design can be seen in the proof of its repetition throughout the Chippewas of Nawash Community, and potentially beyond.

Conclusion

The Warrior Home team incorporated a variety of strategies to ensure a resilient design. For instance, the building envelope control layers were optimized to mitigate moisture penetration and build-up, and the structural components were designed with a high degree of redundancy to be able to endure disaster events. Enhanced insulation provides protection against the location's wide fluctuations in temperature, and heat recovery units controls the homes humidity. In this way, the long-term durability of the home is ensured.

Designed and Built for an Affordable and Sustainable Future

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